CHAPTER 37
HEALTH PHYSICS

Health Physics
- Concerned with providing occupational radiation protection & minimizing radiation dose to the public

Health Physicist
- A radiation scientist who is concerned with the research, teaching or operational aspects of radiation safety

RADIATION & HEALTH

We Practice ALARA
- *Rationale:* the linear nonthreshold radiation dose-relationship (LNT) for stochastic effects
  - *Examples:* cancer, leukemia & genetic effects

Cardinal Principles of Radiation Protection
- *Purpose:* designed to minimize the radiation exposure of patients & personnel
- *Time:* keep the time of exposure to radiation as short as possible
- *Distance:* maintain as large a distance as possible between the source of radiation & the exposure person
- *Shielding:* insert shielding material between the radiation source & the exposed

Minimize Time
- The time of exposure should be kept to a minimum
  - *Radiography:* to reduce motion blur
  - *Fluoroscopy:* to reduce patient & personnel exposure
- Radiation dose is directly related to the duration of exposure
- Exposure = Exposure Rate x Exposure Time

Fluoroscopic Footswitch
- Sequencing on-off rather than continuous on during examination

5-Minute Reset Timer
- It reminds the radiologist that a considerable amount of fluoroscopic time has elapsed

Fluoroscopic Procedure
- It takes less than 5 minutes

Interventional Radiology Procedure
- It takes more than 5 minutes

Maximize Distance
- Radiation dose is inversely related to the distance between the source & the patient
- Assume a point source & apply the inverse square law

Inverse Square Law
- It states that the intensity of radiation at a location is inversely proportional to the square of its distance from the source of radiation
- *Formula:*

$$\frac{I_1 \text{ (Old Exposure)}}{I_2 \text{ (New Exposure)}} = \frac{d_2^2 \text{ (New Distance Squared)}}{d_1^2 \text{ (Old Distance Squared)}}$$

If the distance from the source exceeds five times the source diameter, it can be treated as a point source!

Square Law
- It states that one can compensate for a change in the source-to-object dstance by changing the mAs by the factor SID squared
- It was used to calculate exposure in radiographic technique
- *Formula:*

$$\frac{I_1 \text{ (Old Exposure)}}{I_2 \text{ (New Exposure)}} = \frac{d_1^2 \text{ (Old Distance Squared)}}{d_2^2 \text{ (New Distance Squared)}}$$

X-ray Tube Target
- A point source of radiation

Isoexposure Lines
- Lines that represent positions of equal radiation exposure in the fluoroscopy room
- *Exposure Rate in Normal Position:* 300 mR/hr or 3 mGy_a/hr
- *Two Steps Back:* 5 mR/hr or μGy_a/hr

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During fluoroscopy, the radiologic technologist should remain as afar from the patient as practicable!

Use Shielding
- It greatly reduces the level of radiation exposure
- *Composition:* lead
- 1 TLV = 3.3 HVL
- *Protective Apron:* 0.5 mm Pb
    - Equivalent to 2 HVLs
    - Reduce occupational exposure to 25%

Half-Value Layer (HVL)
- The thickness of absorber necessary to reduce radiation intensity to half its original value

Tenth-Value Layer (TVL)
- The thickness of absorber necessary to reduce radiation intensity to one-tenth its original value

EFFECTIVE DOSE

Radiation Risk Coefficient
- Based on total body radiation exposure

Effective Dose
- The equivalent whole-body dose
- *Formula:* $E = \sum D_t W_t$

Equivalent Whole-Body Dose
- The weighted average of the radiation dose to various organs & tissues

CT of the Abdomen & Pelvis
- *Tissue Dose:* 2000 mrad
- *Effective Dose:* 740 mrem
    - Gonads = (2000)(0.2) = 400
    - Colon = (2000)(0.12) = 240
    - Liver = (2000)(0.05) = 100

PA Chest Radiograph
- *Entrance Skin Dose:* 10 mrad
- *Exit Dose:* 0.1 mrad
- *Average Tissue Dose:* 5 mrad
- *Effective Dose:* 1.35 mrad
    - Lung = (5)(0.12) = 0.6
    - Breast = (5)(0.05) = 0.25
    - Esophagus = (5)(0.05) = 0.25
    - Thyroid = (5)(0.05) = 0.25

WEIGHTING FACTORS FOR VARIOUS TISSUES

Tissue	Tissue Weighting Factor (W_t)
Gonad	0.20
Active bone marrow	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Bladder	0.05
Breast	0.05
Esophagus	0.05
Liver	0.05
Thyroid	0.05
Bone surface	0.01
Skin	0.01

We assume the occupational effective dose to be 10% of the monitor dose!

RADIOLOGIC TERRORISM

Emergency Responder
- Those individuals who must make the first decisions & take the first steps in the early stages of such an event
- *Radiologic Technologists:* first emergency responders
- *Tasks:*
    - To prevent injury & death
    - To attend to the medical needs of victims

Rescue & medical emergencies should be attended to before radiologic concerns are addressed!

Radiologic Devices
- Radiation Exposure Device (RED)

- Radiologic Dispersal Device (RDD)
- Improvised Nuclear Device (IND)

Radiologic terrorism can be addressed safely with an emergency responder's equipment kit!

RED

- A sealed source of radioactive material that directly exposed people
- Decontamination is not required
    - *Rationale:* it will not dispersed radioactive material

RDD

- A bomb that when exploded disperses radioactive contamination over a wide area
- It is not usually life threatening
- It may not be explosive, but rather, radioactive material
- *Forms:* powder, mist, gas into a water supply or ventilation system

IND

- It contains nuclear material that can produce a nuclear explosion
- A nuclear weapon

Radiation Protection Guidance

- With the use of radiation monitoring instruments
- Inner Boundaries: established at an exposure rate of 10 R/hr
- *Outer Boundaries:* established when exposure exceeds 10 mR/hr

Being exposed to radiation does not make an individual radioactive!

Radiation Detection & Measurement Equipment

- *Equipments:*
    - Protective coveralls
    - Shoe covers
    - Protective respiratory devices
    - Contaminated-to-clean step-off pad
- *Detection Apparatus:*
    - It should be readily available to the first responder
    - Capable of measuring radiation exposure levels to 50 R/hr
    - It should emit ambiguous alarms at 10 mR/hr, 10 R/hr & 50 R/hr
- *Storage:* nuclear medicine laboratory

Radioactive contamination is rarely life threatening!